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(54) **Permanent metal to metal joint**

(57) In manufacturing a joint between a metal sheet 22 (e.g. a cathode and a metal member 21 (e.g. a hanger bar) wherein a hole is formed in the sheet, a metal plug 24 is inserted into the hole so that one end of the plug contacts the metal member and the other end lies within or, as shown, projects through to stand proud of the hole, positioning an electrode of a resistance spot welding machine on said other end of the plug and operating the machine thereby to weld the plug to the metal member and to the sheet. The metal member 21 shown is a core within a sheath. The sheet member 22 and core 21 may be of Ti, Zr, Nb, Hf, Ta or alloy thereof, e.g. Ti-Ni, or stainless steel, and the sheath may be of Cu. An insulating layer may be disposed over the metal member and provided with a hole to accommodate the plug.

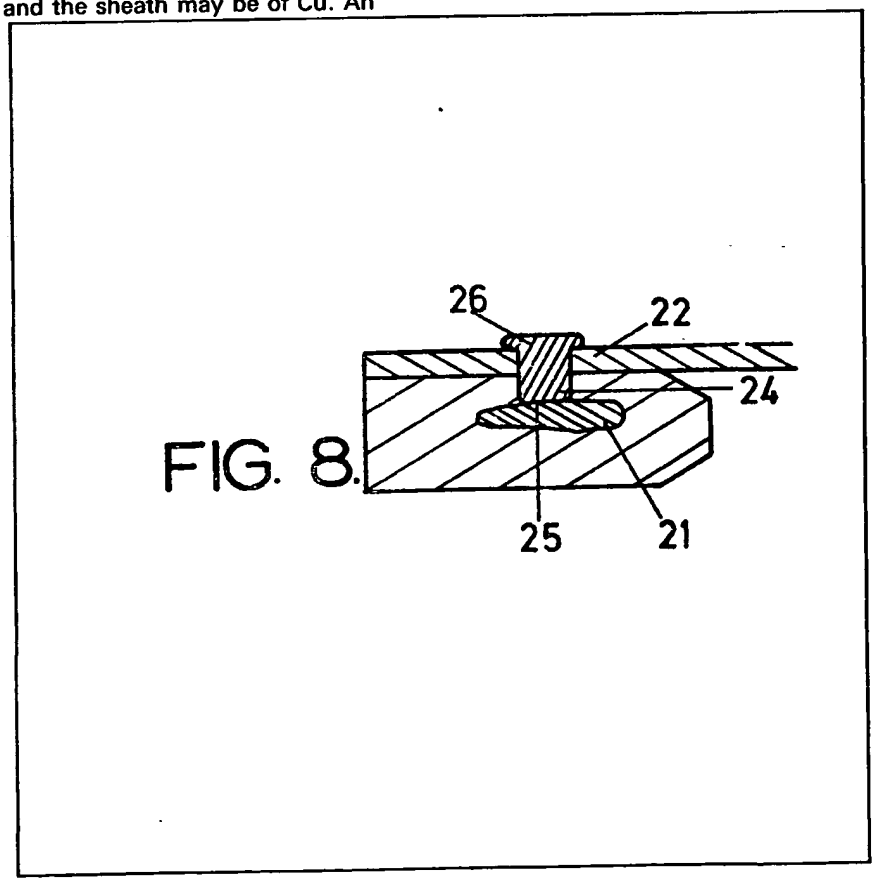

FIG. 8.

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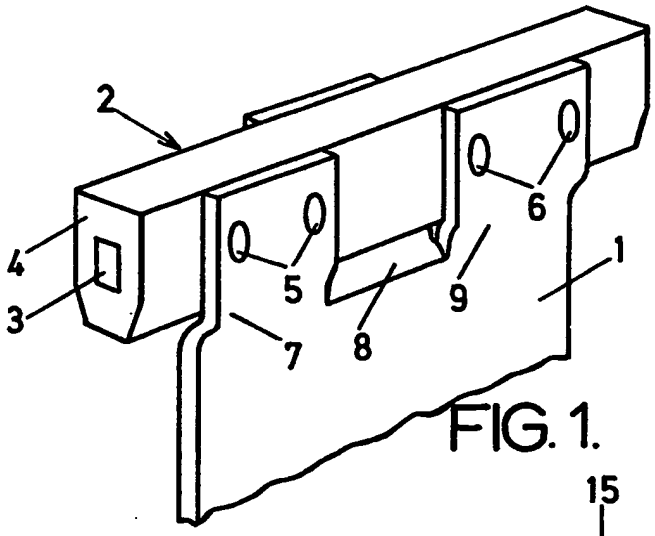

FIG. 1.

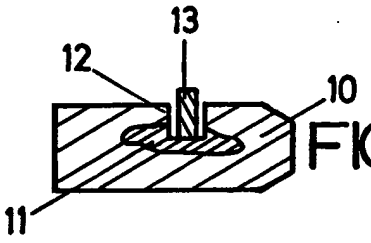

FIG. 2.

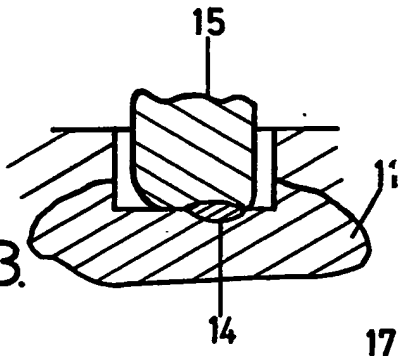

FIG. 3.

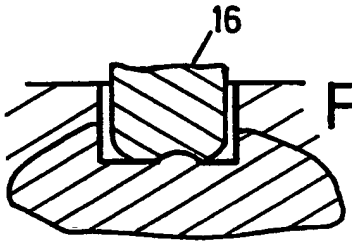

FIG. 4.

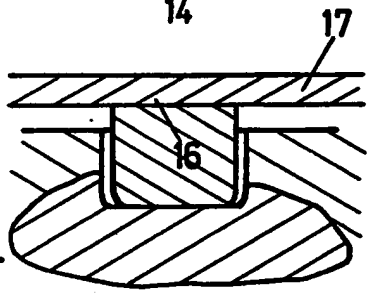

FIG. 5.

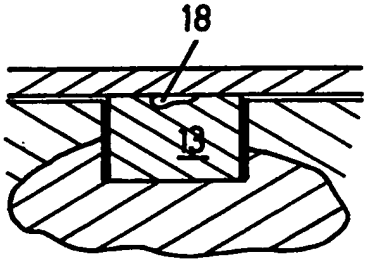

FIG. 6.

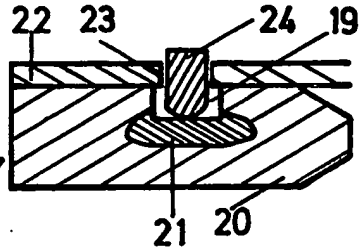

FIG. 7.

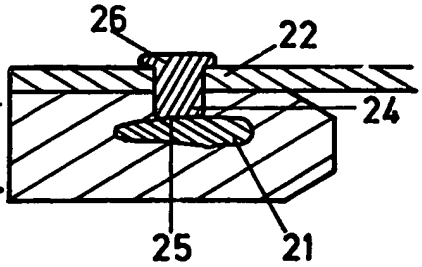

FIG. 8.

SPECIFICATION

Permanent metal to metal joint

This invention relates to joints and has particular, but not exclusive, reference to joints used to manufacture cathode sheet and hanger bar assemblies.

The introduction of permanent titanium cathode sheets for electrowinning and electrorefining has enabled higher current densities to be used in the electrowinning and electrorefining cells. Because of the need to form a reliable high integrity joint between the cathode sheet and the hanger bar all weld constructions of hanger bar and sheet have been introduced. Unfortunately the hanger bars are normally formed of copper and the sheets are frequently formed of a film-forming metal such as titanium or of stainless steel. Because it is difficult to join these two materials elegant new solutions have had to be introduced. One of the solutions is to use a copper hanger bar having a core of titanium, the composite being manufactured by a co-extrusion process. The titanium cathode sheet is then joined to the core by means of an intermediate plug. The existing process utilises a system in which the plug is first of all connected to the core and then the sheet is connected to the plug. This sytem is very reliable but is quite expensive to put into practice.

The present invention is concerned with joints which are more easily manufactured than this particular type of prior art joint.

By the present invention there is provided a method of joining a sheet of metal to a metal member which comprises:

(i) forming a hole in the sheet of metal,

(ii) inserting a metal plug into the hole so that one end of the plug is in contact with the metal member and the other end of the plug stands proud of that surface of the sheet remote from the metal member or lies within the hole in the sheet,

(iii) positioning an electrode of an electrical spot welding machine on the said other end of the plug and

(iv) operating the spot welding machine, whilst applying pressure on the plug by means of the electrode, thereby to weld the plug to the metal member, to spread the plug radially and to weld the plug to the sheet.

Preferably said other end of the plug stands proud of the surface of the sheet.

There may be provided a co-operating hole in the metal member, which may be in the form of a block, in which the plug is located so that the welding takes place within the body of the block.

Preferably the hole in the sheet is of smaller diameter than the hole in the metal member.

The metal member may have a core of a second metal, the hole in the metal member revealing the core, so that the plug interconnectes the sheet and the core. The metal member may be elongate and may comprise an elongate bar of a first metal with an elongate core of a second metal. The first metal may be copper and the second metal may be a film-forming metal, preferably titanium, or stainless steel.

The sheet may be a film-forming metal, preferably titanium, or may be a sheet of an alloy of a film-forming metal, such as an alloy of titanium and nickel. Alternatively the sheet may be of stainless steel. A particularly preferred alloy is 50 atomic % nickel and 50 atomic % titanium.

There may be a layer of insulating material over the metal member, the insulating material being provided with a hole through which the plug can make contact with the metal member.

The plug may have a domed end at its first end. The plug may be an interference fit in the hole.

By a film-forming metal as used herein is meant a metal chosen from the group titanium, zirconium, niobium, hafnium or tantalum or an alloy of one or more of these metals having comparable anodic properties.

The present invention also provides a cathode comprising a sheet of a film-forming metal, preferably titanium, or of stainless steel, joined to a hanger bar comprising an elongate block of copper having a core of a film-forming metal, preferably titanium, or stainless steel, the sheet and the block being joined by any of the methods defined above.

By way of example embodiments of the present invention will now be described with reference to the accompanying drawings of which:—

Figure 1 shows a perspective view of a cathode;

Figures 2–6 are sequence drawings showing the manufacture of a joint according to a prior art method; and

Figures 7 *and* 8 show a method of manufacturing a joint according to the invention.

Fig. 1 shows a cathode assembly which comprises a sheet of titanium 1 joined to a hanger bar shown generally at 2. The hanger bar comprises a titanium core 3 metallurgically bonded to an outer shaft 4 of copper. The sheet 1 is bonded to the core by means of joints such as 5 and 6 which interconnect the sheet and core by means of plugs (not shown in Figure 1). As can be seen from the drawing the sheet 1 is provided with three legs 7, 8 and 9 which are cranked and staggered so that two legs are joined to one side of the hanger bar and one leg is joined to

the other side.

The joints 5 and 6 have hitherto been manufactured as shown in Figs. 2–6. These show cross-sections of the joint in various stages of assembly. Referring to Figure 2 this shows a copper sheath 10 which has a titanium core 11. The hole 12 is drilled through the sheath 10 into the core 11. A stud 13 is positioned into the hole 12. The stud is then spot welded as at 14 (Figure 3) to the core 11. The outer end of the stud 15 becomes distorted during the spot welding operation. It is then necessary to dress the outer end of the stud to form a flat surface such as that shown at 16 in Figure 4. A sheet of titanium 17 is then laid onto the flat surface 16 as shown in Figure 5. Finally the sheet 17 is spot welded to the stud 13 as at 18 to form the final joint. It can be seen that there are a number of operations involved in this manufacturing route.

Referring now to Figures 7 and 8 which illustrate the invention, it can be seen how the present invention provides a novel method which is much quicker and easier to operate than the prior art method. Again a hole 19 is provided in the sheath of copper 20 which extends into the core 21 of titanium. A sheet of titanium 22 is laid onto the core and a hole 23 (of smaller diameter than hole 19) is drilled in the titanium to be aligned with the hole 19. The plug of titanium 24 is then inserted through the hole 23 to come into contact with the core 21. An electrode of a spot welding machine is then applied to the top of the plug 24 and a single welding operation is carried out. This simultaneously forms a weld between the core 21 and the plug 24 at 25, and because the plug is heated to a high temperature by the spot welding operation it deforms outwardly in the manner of a rivet to contact the sheet 22 and is welded to the sheet around the periphery of the hole by 23 and beneath the cap 26 formed by the top of the plug.

It can be seen, therefore, that the whole joint is manufactured by a single spot welding operation.

It will be appreciated that although it is preferable for the plug to stand proud of the sheet during the welding operation—so that a cap may be formed for thicker sheets—it would be possbible for the plug to lie with its second or outer end within the hole in the sheet and a weld would simply be formed between the edge of the plug and the periphery of the hole in the sheet.

CLAIMS

1. A method of joining a sheet of metal to a metal member which comprises:
   (i) forming a hole in the sheet of metal,
   (ii) inserting a metal plug into the hole so that one end of the plug is in contact with the metal member and the other end of the plug stands proud of that surface of the sheet remote from the metal member or lies within the hole in the sheet,
   (iii) positioning an electrode of an electrical spot welding machine on the said other end of the plug and
   (iv) operating the spot welding machine, whilst applying pressure on the plug by means of the electrode, thereby to weld the plug to the metal member, to spread the plug radially and to weld the plug to the sheet.

2. A method as claimed in Claim 1 wherein the said other end of the plug stands proud of that surface of the sheet remote from the metal member and during spot welding deforms radially to such an extent that it forms a head adjacent to said surface having a greater diameter than the diameter of the hole in the sheet.

3. A method as claimed in Claim 1 or Claim 2 wherein a cavity is preformed in said metal member for receiving said one end of the plug whereby the plug is welded to the metal member within the body of the metal member.

4. A method as claimed in any one of Claims 1 to 3 wherein the plug is an interference fit in the hole in the sheet.

5. A method as claimed in any one of Claims 1 to 4 wherein the sheet of metal and the metal member comprise a film-forming metal or an alloy thereof or stainless steel and the metal plug comprises a metal that is weldable to both the sheet of metal and the metal member.

6. A method as claimed in Claim 5 wherein the metal member comprises a core of a film-forming metal or of an alloy thereof having a copper sheath.

7. A method of joining a sheet of metal to a metal member substantially as hereinbefore described with reference to, and as illustrated in, Figure 7 and Figure 8 of the accompanying drawings.

8. A sheet of metal joined to a metal member by a method as claimed in any one of Claims 1 to 7.

9. A cathode for use in electrowinning or electrorefining comprising a sheet of film-forming metal, an alloy thereof or stainless steel joined to a hanger bar comprising a core of a film-forming metal, an alloy thereof or stainless steel and a sheath of copper by a method as claimed in any one of Claims 5 to 7.

10. A cathode as claimed in Claim 9 substantially as hereinbefore described with reference to and as illustrated in Figure 1, Figure 7 and Figure 8 of the accompanying drawings.

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